Outcrop of Mesoproterozoic metasedimentary rock riddled with ptygmatically folded leucocratic sills and dikes. This particular exposure can be found in the southeast corner of the Lick Point 7.5' quadrangle, northeast of Elk City, Idaho. Pocket knife, 3.54 in (9 cm) long, for scale.
What a great year to be a geologist, and even more so, what a great year to be a geologist in Idaho!

Idaho’s mineral endowment is making national headlines as the U.S., with bipartisan support, increases its investments for securing reliable and sustainable sources of critical minerals. Idaho’s cobalt belt is experiencing a tremendous increase in exploration in both new and historic districts, while production of cobalt is expected by the end of the year. Many other commodities have also been closely looked at, from both small local companies and international “giants”. Antimony, tin, and rare earth elements, to name a few, have (re) appeared among the most wanted, and with them also the precious metals that often accompany the mineralization are experiencing a new revival.

As exploration ramps up, legitimate concerns for environmentally sustainable production also increase and guaranteeing the safeguard of Idaho’s unique habitats is paramount.

In all this, the Idaho Geological Survey (IGS) plays the fundamental role of providing sound and unbiased scientific information to all stakeholders, as in its century-long tradition.

IGS has increased its geologic mapping efforts in partnership with the U.S. Geological Survey (USGS) Earth Mapping Resources Initiative (Earth MRI) program and was able to co-sponsor a regional geophysical survey in the cobalt belt, with the partial support of local operators. Building on career-long connections and collaborations, IGS staff initiated a field forum open to representatives of industry, academia, and government with the intention of providing a venue to explore synergies and seed collaborations. We expect to continue this for the foreseeable future.

Parallel to the bustling scene of a revived exploration, IGS continues its mission in many other areas to serve the interest of Idaho’s constituents. We are exploring options to establish a skeleton earthquake monitoring network, filling a gap in data collection that will help the seismological community and our understanding of geologic hazards and resources for decades, in an effort to bring monitoring capabilities to a level adequate to a modern geological survey.

As water continues to be central in Idaho’s economy, IGS is working in partnership with state and federal agencies to contribute to the characterization and understanding of decreasing groundwater levels in southern Idaho’s aquifers.

All of this and more of the many activities of the IGS is captured in the pages of this report. Thank you for taking the time to learn more about the operations of the IGS. I hope you will enjoy the opportunity to become more familiar with what we do in the service of Idaho’s constituents, wealth, safety, resiliency, and wellbeing.

Claudio Berti
Director and State Geologist
STATEWIDE UPDATES

• Completed a new investigation of the Halfway Gulch fault, funded by the USGS Earthquake Hazards Program, which included detailed mapping of the fault and adjacent surficial deposits. Samples have been collected and are being analyzed to provide age constraints on the timing and history of past earthquakes.

• Participated in a mapping and paleoseismic trenching investigation of the Deadwood fault in collaboration with the U.S. Bureau of Reclamation (USBR). The USBR will use the resulting earthquake history, slip rate, and recurrence interval to assess the seismic vulnerability to the Deadwood dam.

• Monitored seismic activity as recorded by the USGS earthquake catalog. During FY 2022, there were a total of 1,385 earthquakes recorded including:
  - 4 earthquakes of M4.0
  - 42 earthquakes M3.0-M3.9
  - 686 earthquakes M2.0-M2.9
  - 653 earthquakes <M2.0

• Led the compilation and synthesis of Idaho datasets for the INGENIOUS (INnovative Geothermal Exploration through Novel Investigations Of Undiscovered Systems) project. Supporting datasets included: spring and well temperatures, Quaternary faults, paleo-geothermal features, and Quaternary volcanic deposits and eruptive centers.

• Continued to work with the USGS on a report summarizing groundwater budgets spanning 2000-2019 at a watershed scale for the Big Lost River Basin in south-central Idaho. The project is part of a larger study conducted during 2018-2021 with Idaho Department of Water Resources (IDWR) and the USGS with Department of Energy Supplemental Environmental Project funding. The IGS groundwater budget report is planned for publication by the USGS in FY 2023 as a separate chapter in a USGS scientific investigation report.

• Continued work on STATEMAP:
  Mapped two 7.5' quadrangles, Lick Point and Black Hawk Mountain, at 1:24,000 scale. Progress has also been made on filling the gaps between these 7.5' quadrangles. As such, the entire western half of the Elk City 30' x 60' has been mapped at a minimum 1:75,000 scale. This new work warrants a few notable updates on the geology of the Elk City area:
  - In addition to the geologic mapping, the IGS has been building a robust geochronology dataset for the region, which has suffered from a paucity of analytical data. Currently, these data include 23 detrital zircon and six igneous zircon U-Pb ages.

• Mining activity has been resurgent in the Elk City vicinity in recent years, with multiple gold companies exploring new targets. The 1:24,000 scale mapping by IGS complements this mine-site scale work; the IGS has informally collaborated with Idaho Champion and Endomines Idaho LLC on surface drilling projects and underground ore deposit workings, respectively.

• Continued work in the Salmon area, with a focus on the geology of the Beartrack mine area and the nearby Arnett Creek gold prospect.

• Continued geologic mapping of the Weiser 30' x 60' quad by completing the Mann Creek NW and Birding Island 7.5' quadrangles.
Continued geologic mapping of the east half of the Preston 30’ x 60’ quad by completing the Montpelier 7.5’ quadrangle.

Where coverage is available, IGS augments mapping efforts with LiDAR-derived imagery. Imagery interpretation has led to the identification of previously unmapped faults and the location of other unconstrained tectonic lineaments, significantly improving our understanding of their contribution to geologic hazards and their significance in the structural and tectonic history of a given area.

- Implemented the Geologic Map Schema (GeMS) database standard for all new geologic mapping activities, an effort IGS initiated in FY 2021.

Adoption of the GeMS standard is central to IGS mapping activities as it promotes and ensures the integrity, accessibility, and interoperability of digital geologic map data and aligns IGS products to the requirements of the USGS.

- Increased the coverage of GeMS-compliant geologic map databases to now include more than 131 7.5’ quadrangles in five project areas throughout Idaho. By the end of FY 2022, approximately 21% of areas mapped by IGS have been brought into GeMS compliance.

- Implemented the Geologic Map Schema (GeMS) database standard for all new geologic mapping activities, an effort IGS initiated in FY 2021.

- Published three Digital Analytical Datasets, three Technical Reports, and five Digital Web Maps. Notably, three of the five published Digital Web Maps include the first GeMS-compliant GIS packages published by IGS.

- Reported on Idaho’s mining and exploration activity (Annual mining review materials can be found on the IGS Current & Historic Mining Activity Web Page under Regional Development):

Hecla’s Lucky Friday in the Silver Valley mine was at full production.

Exploration drills continued to discover new resources at the Galena mine of Americas Gold and Silver Corporation.

Development work started at the Bunker Hill mine, with an objective of reopening the Pb-Zn giant.

Idaho Strategic Resources (formerly New Jersey Mining) continued to mine gold at Murray.

The three large phosphate plants and mines were operating in Caribou County.

The largest exploration projects, all for gold and silver, were operated by Integra Resources at De Lamar, Revival Gold at Beartrack and Arnett Creek, and Liberty Gold at Black Pine. Each project discovered new resources.

Two large projects in the Idaho Cobalt Belt continued: Jervois, an Australian firm, was developing the Idaho Cobalt Operation as an underground Cu-Co-Au mine, with production planned by the end of 2022, and Electra Battery Materials (formerly First Cobalt) was drilling at the Iron Creek project on the southeast end of the belt.

Exploration drilling for cobalt was also underway in mid-2022 at two other locales, the Blackpine deposit and the Colson Creek deposit.

- Retrieved and reviewed the extensive collection of mineral records that was donated by Don Adair, a well-known Boise-based consulting geologist.

- Improved Mines and Prospects database (Mines) and continued efforts to expand content and improve accuracy. Functionality was added for filtering Mines web app searches by company names associated with mining properties.
• Digitized 45 new Abandoned Mine Land videos adding about five additional hours of audio-visual footage to our collection. Currently, there are 139 geolocated video clips that are discoverable and available for download via the Mines web app and for streaming through the IGS YouTube channel.

• Digitized the Grangeville 1° x 2° quadrangle mineral property files resulting in the availability of 280 files for the quad within our database.

• Reviewed references within Mines for vanadium and fluorite critical mineral deposits in Idaho both within and outside of Idaho’s phosphate district. Select historical analytical data from these sources were converted to modern tabular format.

• Digitized nine additional Idaho State Annual Mine Inspector Reports (1910-1919) and posted on the IGS Current & Historic Mining Activity Web Page, with 1903 data-mined for incorporation into the Mines database.

• Data-mined and incorporated two Regional Development years (1991-1992) into the Mines database.

• Converted well logs for Idaho oil and gas wells from pdf log data to the more versatile LAS industry-standard format, bringing the total to 228 (212 new).

• Redesigned the IGS Oil and Gas database for increased functionality to deliver LAS files via the Oil and Gas web app as free downloads.

• Scanned and cataloged unpublished or difficult to locate references concerning Idaho faults, bringing the total to 408.

• Created a digital warehouse of 104 scanned Idaho-related USBM documents that is currently hosted on the IGS website.

FY 2022 By the Numbers

92
Collaborating partners

13
Active awards

6
Funding partners

14
Publications

25
Professional presentations

6
Educational presentations

11
Web products

9
Outreach Activities

12
Media interviews
RESEARCH HIGHLIGHTS

Sawtooth Fault Mapping and Trenching

The Sawtooth fault in central Idaho has long been recognized as a potentially active fault. In response to the March 31, 2020 magnitude 6.5 Stanley earthquake, the IGS has been studying the Sawtooth fault to better understand its seismic hazard. With funding from the USGS Earthquake Hazards Program, IGS has worked with academic and industry collaborators to conduct new, detailed mapping of the Sawtooth fault and collect geochronology samples to determine the age of past earthquakes. New high-resolution LiDAR topographic data revealed that the north end of the Sawtooth fault consists of three parallel strands. All three northern strands appear to be recently active, but it is not clear if they rupture with the rest of the Sawtooth fault, or if they are even part of the same structure. Mapping also revealed several previously unknown fault scarps at the southern end of the Sawtooth fault. This mapping greatly improves the characterization of the fault. In order to constrain the age of past earthquake activity on the Sawtooth fault, we collected samples of large boulders deposited at the surface of glacial moraines and outwash fans. These samples record the surface exposure history of the boulders and will date landforms that we use as fault offset markers.

LiDAR hillshade map of the Sawtooth fault scarp crossing Crooked Creek on the east side of the Sawtooth Range. Image on left is uninterpreted LiDAR, and image on right shows mapped fault.
In collaboration with USGS scientists, IGS also helped conduct a paleoseismic investigation of the Sawtooth fault. This consisted of digging a trench across the fault scarp along the main strand of the Sawtooth fault to map and interpret the soil stratigraphy across the fault. The trench exposed evidence of at least one surface rupturing earthquake event along a distributed fault zone. Several samples were collected from the trench to constrain the ages of stratigraphic units. Those samples are currently being processed and analyzed and will assist in defining the Holocene stratigraphy of the units involved in the faulting.

Work on the Sawtooth fault project will continue in the near future with additional paleoseismic trenching and geochronology on newly recognized segments.
Raft River Basin Hydrogeologic Investigation

Following completion of a one-year study (Phase 1) in 2020, IGS commenced a three-year hydrogeologic investigation (Phase 2) of the Raft River Basin in southern Idaho and northern Utah. The project spans 2021-2023, in partnership with the IDWR, with funding to IGS by the Idaho Water Resources Board. Overall project goals are to address declining groundwater level trends in the Raft River Basin, with the study findings and new monitoring infrastructure intended to inform water users and resource managers. IGS is preparing a hydrogeologic framework and groundwater budget. A three-dimensional geologic model based on available drillers’ logs, IDWR’s monitoring well network, and geologic mapping will supplement the framework. The groundwater budget will include representative average, dry, and wet years. In spring 2022, IDWR installed 12 new monitoring wells for incorporation into the existing monitoring well network. IDWR plans to instrument the wells with dedicated pressure transducer equipment and collect groundwater quality samples. During FY 2022, IDWR installed additional stream monitoring equipment as part of the investigation. IGS publication of the study findings is planned for winter 2023.
With funding from the USGS STATEMAP program, the IGS has continued to conduct detailed mapping of the Elk City 30’ x 60’ quadrangle in north-central Idaho. This work has yielded a refined model for a major structural complex west of the town of Elk City called the Orogrande shear zone. The Orogrande shear zone (OSZ) has been an enigmatic structural corridor since 1934, when geologists first defined the half-mile wide mineralized shear zone near Orogrande, Idaho. Recent detailed mapping and new U-Pb geochronology has allowed us to better characterize the deformation styles and timing of the OSZ and superposed younger faulting. The OSZ is a ~0.6 mi (1 km) wide, north-northeast-striking structural corridor characterized by a high-strain zone of diffuse deformation usually observed in outcrop as mylonite. This diffuse, relatively wide belt of deformation can be traced from the hamlet of Orogrande to the north across the South Fork of the Clearwater River. Kinematic data from the OSZ indicate that this deformation was dextral transpressional; i.e., it accommodated both compressional and right-hand lateral strain. Additionally, new U-Pb zircon crystallization ages from intrusive igneous rocks within and near the OSZ offer temporal constraints on this deformation. Granodiorite rocks of the Idaho batholith as young as ~83 Ma are mylonitized, while undeformed shallow intrusive rhyolite yielding an age of ~48 Ma crosscuts the ductile fabric. These ages and crosscutting relationships indicate that deformation along the OSZ was no older than Late Cretaceous and no younger than early Eocene.
Since the Late Cretaceous, the ductile OSZ has been exhumed and dismembered by brittle, steeply east-dipping, normal faults. The most prominent of these faults are the north-striking, down-to-the-east, Crooked River and Buffalo Gulch faults.

This new work by the IGS is beneficial on both the societal and economic fronts. First, this data is useful to the local gold companies and mining operations who are looking for updated information on the general geology and ore deposit formation and geometry. This past spring an IGS mapping geologist worked with Endomines Idaho on site at their Friday Mine property, one of the few active underground mines along the OSZ. Sharing and trading ideas and information between mine-site scale geologists and regional scale mapping geologists is powerful with both parties gaining much-needed insight. Second, the Survey’s mapping is augmented with LiDAR-derived imagery, which has allowed IGS to accurately locate the younger faults in the area. Fault-line scarps along the Crooked River and Buffalo Gulch fault traces have been recently identified from this utilization of LiDAR, which could indicate that these structures have been active within the last ~6 Ma.
Preston STATEMAP Project

The FY 2022 STATEMAP Preston project saw the completion of the geologic map of the Montpelier 7.5’ quadrangle. The geologic highlights of the quadrangle include the late Paleozoic and Mesozoic sedimentary strata that were emplaced by the Idaho-Wyoming fold and thrust belt, Eocene to Miocene sedimentary terrestrial basin deposits, Quaternary surficial deposits related to the Bear River and Bear Lake, and normal faulting related to Basin and Range extension. The map was an important project as it incorporates the municipality of Montpelier, the largest town and seat of Bear Lake County, as well as active fault scarps related to the east Bear Lake fault.

The east Bear Lake fault is a Basin and Range style normal fault that initiated in the Miocene dropping the Bear Lake and the Bear River valleys down on the west relative to the Preuss Range. Fault scarps of the east Bear Lake fault were most recently identified by IGS geologist Zach Lifton and geologists from the Utah Geological Survey (UGS). New hillshade imagery and terrain models derived from recently collected LiDAR data has allowed geologists to identify fault scarps more readily in swamps and lands heavily modified by agricultural development. Most recently, IGS and UGS completed a National Earthquake Hazards Reduction Program (NEHRP) funded assessment of fault scarps in the area from Utah to Soda Springs, Idaho. IGS staff geologists worked with landowners to gain access to walk along the fault scarps, take measurements, and examine evidence like marsh development on the down-thrown blocks. The fault scarps continue north through the eastern part of Montpelier. However, they are much more difficult to ascertain in person due to infrastructure and urban development but are readily apparent on the LiDAR-derived imagery.

Future work in the Preston 30’ x 60’ quad will continue mapping the east Bear Lake fault scarps as they progress south along Bear Lake and eventually map surficial appearances on the west side of the Bear Lake graben of the west Bear Lake fault.

Identifying and mapping east Bear Lake fault.
A) Fault seen in hill shade imagery derived from LiDAR.
B) Interpretation of fault location.
C) 10-12 ft (3.0-3.7 m) of offset. Person for scale.
D) East Bear Lake fault mapped as it progresses north through the town of Montpelier.
Idaho Cobalt Belt Study

New high-tech products and materials needed for the transition to a carbon neutral energy portfolio require the use of several minerals and elements for which the U.S. is currently heavily reliant on markets dominated by foreign countries. The USGS has released and updates a list of commodities deemed critical to the national economy and security and manages a program aimed at the identification of critical mineral resources – Earth MRI. IGS is working with the Earth MRI program to identify critical mineral resources in the cobalt belt of eastern Idaho, a northwest-trending zone of cobalt, copper, gold, and anomalous rare earth elements (REEs) west of Salmon. IGS aims to provide the public with data from the cobalt belt gained through geologic mapping, field reconnaissance sampling of rocks and stream sediments, mineralogic characterization, and data preservation methods, such as digitizing data from historic geochemical surveys of the region.

The Idaho cobalt belt consists of strata-bound copper-cobalt deposits that have a complex history. An important contribution by the IGS is the collection of surface measurements of magnetic susceptibility (magnetite content) and uranium-thorium-potassium content to better understand the distribution, age, and controls of mineralization. These efforts will also help with interpretation of the cooperative USGS-Industry aeromagnetic and radiometric survey in this area that was flown in September and October of 2021 and recently released (Phelps, G.A., 2022, Airborne magnetic and radiometric survey, Idaho Cobalt Belt, Central Idaho, 2021 - Magnetic and Radiometric Data. U.S. Geological Survey data release, https://doi.org/10.5066/P9TLBM4U).

Index map showing location of the Idaho cobalt belt (blue diagonal pattern) and progress with geologic mapping in the area.
Notable Outcomes

• Completed the initial USGS Earth MRI (critical minerals) project in the Idaho cobalt belt resulting in publication of geologic maps for three 7.5’ quadrangles (Cobalt, Digital Web Map 199; Degan Mountain, Digital Web Map 200; and Taylor Mountain, Digital Web Map 201) along with a compilation of the geology of the area around the historic Blackbird mine and the newly developed Ram property (Technical Report 22-02).

• Supported exploration efforts in the Idaho cobalt belt by digitizing and posting historic stream-sediment analyses using funding from the USGS National Geological and Geophysical Data Preservation Program (NGGDPP).

• Hosted the first Salmon Field Forum, bringing together over 20 representatives from industry, IGS, USGS, and various academic institutions for presentations and a field trip to the Iron Creek copper-cobalt property.

• Revisited and simplified the regional Precambrian stratigraphy that correlates strata in the Yellowjacket and Blackbird mine areas in the west with the Lemhi Group, Swauger Formation, and Apple Creek Formations eastward into the Lemhi Range.

• Took outcrop measurements that indicated that the lowermost strata (Lemhi Group) have at least one interval of elevated magnetite concentrations and the lower part of the uppermost strata (Apple Creek Formation) has the highest concentrations; mudcracks in these rocks are evidence of subaerial exposure during deposition.

• Speculated that an early (Precambrian) style of Cu-Co mineralization may have involved preferential deposition from metal-bearing brines at the upper and lower contacts of the banded siltite member of the Apple Creek Formation. Later vein mineralization and remobilization of copper sulfide (chalcopyrite) have obscured the earlier copper-cobalt mineralization in rocks at higher metamorphic grade, but remnants may be present at the Iron Creek deposit in the southeast part of the Idaho cobalt belt.

• Collected stream-sediment samples and mineralized and unmineralized rock samples. This effort is ongoing, and these samples provide baseline compositional data for copper-cobalt concentrations. Historic stream-sediment sampling results have also been digitized and posted on the IGS website (Digital Analytical Data 17 and 18).

• Started mapping two additional 7.5’ quadrangles (Blackbird Creek and Opal Lake) which will continue next year. Field work involved camping along Panther Creek to effectively reach remote areas in these two quadrangles.
Magnetite in the Iron Creek Co-Cu Area, Lemhi County

A focused petrographic study of the enigmatic zones of magnetite occurrences and their relationship to copper-cobalt mineralization at the Iron Creek deposit started through funding and collaboration with Electra Battery Materials. Initial activity included review of diamond drill core through the deposit and preparation of polished thin sections from core and surface samples provided by Electra. Petrographic review of the initial sample suite was underway in late FY 2022, which revealed many interesting features suggesting that some of the iron oxides are related to heavy mineral concentrations in the Mesoproterozoic sediments, but other textures show complex relationships in the deformed strata.

Idaho-sourced Rare Earth Elements Characterization and Extraction at Diamond Creek

IGS is participating in a new University of Idaho collaborative project funded through the Idaho Department of Commerce Idaho Global Entrepreneurial Mission (IGEM) grant program in cooperation with industry partner Idaho Strategic Resources (ISR). The project will focus on research and development of a new technique for extracting REEs. ISR will be drilling to evaluate rare earth mineralization at the Diamond Creek area northwest of Salmon in Lemhi County, providing the raw material for the study. Like the Lemhi Pass area, exposed veins at Diamond Creek consist partly of oxidized thorium – rare earth minerals. Some veins also have a poorly understood gold credit. The IGEM program funds research collaborations between university and industry partners to help bring viable technologies to market. The project lead is Assistant Professor Amin Mirkouei, from the UI College of Engineering at Idaho Falls, and will be investigating biomining and other types of biological recovery for REEs. IGS’ contribution will be assisting with mineralogy and other geological characterization.
Origins of Oil and Gas beneath the Western Snake River Plain (WSRP)

Crude oil and natural gas originate from the remains of dead animals and plants that have been incorporated into layers of sediment and buried to depths where heat and pressure convert them to hydrocarbons. Once formed, hydrocarbon molecules move vertically through the overburden, where they either reach the surface and escape into the atmosphere or become trapped beneath an impermeable layer to form a subsurface accumulation. Resulting accumulations consist of mixtures of hydrocarbons whose chemical makeup varies in systematic ways depending on factors related to its source, maturity, and migration history. The application of geochemical techniques can help resolve the impact of these factors on fluid composition and assist exploration efforts by clarifying the source kitchen and its potential for producing hydrocarbons.

The Western Snake River Plain (WSRP) of southwestern Idaho and eastern Oregon overlies a Neogene-aged rift basin that contains Idaho’s only producing petroleum system. Although modest in size, conventional accumulations of lean gas, wet gas, and some oil have recently been discovered in the northern part of the basin. Reservoirs occur at three stratigraphic levels informally labeled the Hamilton, Harmon, and Willow based on local names in the area they were first discovered. The Harmon and Willow sands were deposited by fluvial channels and shallow-water deltas within the confines of a narrow graben structure, whereas the younger Hamilton sands are widely distributed across the basin as toe-of-slope fans associated with a large lacustrine delta. Hydrocarbon accumulations in all cases occur near graben margins where faulting has created conduits for the migration of gas and fluids and structures capable of trapping them. Gas and fluid samples were collected by the IGS from sixteen wells in the producing areas of the basin and geochemically analyzed to understand the origin and genesis of the hydrocarbons. Geochemical techniques applied to the samples include stable isotopes of carbon and hydrogen, compositional analysis from gas chromatography, and identification of specific organic compounds (biomarkers) via gas chromatography coupled with mass spectrometry.

Summary of Key Findings

- Natural gas from the Willow and Harmon fields is thermogenic in origin whereas the Hamilton field is a mix of biogenic gas produced in the shallow subsurface and thermogenic gas produced in the deep subsurface.
- The ratio of Pristane and Phytane in the fluid suggests the organic matter is a mixture of type II and type III kerogen and capable of producing both gas and oil.
- Maturity estimates based on aromatic compounds in the fluids suggest the hydrocarbons were generated at depths of 5,000 to 8,000 ft (1,524 to 2,438 m).
- The proportion of Sterane biomarkers indicates the hydrocarbons are derived from both terrestrial plant matter and lacustrine phytoplankton, a mixture consistent with deposition in a nearshore lacustrine setting.
- The high degree of similarity between the Harmon and Willow samples suggests they were generated from the same source kitchen.

A) Map illustrating late Miocene structures associated with the WSRP and location of the Willow, Harmon, and Hamilton fields. Samples were collected from numbered wells for geochemical analysis. B) Composite lithologic column illustrating late Miocene to Pliocene tectono-stratigraphic sequences and producing sands within the basin. Harmon sands are not present at the Willow Field.
Established in 1910 as means to track production and address mine-related hazards, the U.S. Bureau of Mines (USBM) filled a research niche of economic geology focused on mineral resource development, mine safety, and ore processing. The work often overlapped with USGS efforts, and much of the intellectual assets were absorbed by USGS when the Bureau was dissolved in 1995.

The efforts of the USBM researchers remain valuable resources to industry today. These resources are largely irreproducible and were not continued by the USGS or other agencies. The published data from USBM are out-of-print and can be extremely difficult to discover and obtain, even as modern research continues to source these data.

IGS curates a large collection of Idaho-related USBM publications and some documents and manuscripts by researchers never published or made publicly available. While USGS efforts have declassified some material and is increasing exposure for these data, the IGS has positioned itself as a repository and resource for anyone seeking USBM data related to Idaho.

The IGS actively pursues obtaining USBM publications and unpublished data and catalogs and renders them discoverable and available to the public. Through funding from Idaho Department of Lands and the USGS National Geologic and Geophysical Data Preservation Program, data from these documents are being harvested and included in our Mines and Prospects of Idaho database and available for download via IGS’ Mines web application. Furthermore, we have constructed a web page that facilitates search engines to increase discoverability of these data and serves as a warehouse for delivery.
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Abandoned Mine Lands
Idaho Department of Water Resources
Big Lost River Valley | Raft River Valley

Electra Battery Materials Corporation
Petrochemical Study of Magnetite in the Iron Creek Co-Cu Area
University of Nevada, Reno
INGENIOUS project
U.S. Geological Survey
STATEMAP | Data Preservation | NEHRP | Earth MRI

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Association of American State Geologists
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Governor’s Office, State of Idaho
Headwater Gold Inc.
Hecla Mining Company
Hells Canyon Gem Club
Ice Age Floods Institute
Idaho Department of Commerce
Idaho Department of Environmental Quality
Idaho Department of Lands
Idaho Ground Water Monitoring Technical Committee
Idaho Mining Association
Idaho Museum of Mining and Geology
Idaho National Lab
Idaho Office of Emergency Management
Idaho Office of Energy and Mineral Resources
Idaho Oil and Gas Conservation Commission
Idaho Public Television
Idaho State University
Idaho Strategic Resources Inc.
Idaho Transportation Department
Indiana State University
Integra Resources
Intermountain Forestry Cooperative
Incorporated Research Institutions for Seismology Portable Array Seismic Studies of the Continental Lithosphere (IRIS PASSCAL)
Instrumental Software Technology Inc. (ISTI)
Lehigh University
Letts Consultants International
Lewis-Clark State College
Montana Bureau of Mines and Geology
Nanometrics
National Academy of Science
Nevada Bureau of Mines and Geology
Northwest Knowledge Network
Oregon Department of Geology and Mineral Industries
Orma J. Smith Museum of Natural History
Perpetua Resources
PetroStrat Services
Premium Exploration Inc.
Revival Gold
Snake River Oil and Gas
Schlumberger Petroleum Services
Society of Mining Engineers, Boise Section
Texas and Oklahoma Coal Company
Tobacco Root Geological Society
U.S. Bureau of Land Management
U.S. Bureau of Reclamation
U.S.D.A., Agriculture Research Service
U.S. Forest Service
U.S. Geological Survey—Minerals Program
U.S. Geological Survey—NEHRP
U.S. Geological Survey—Water Resources Division
U.S. Geological Survey—Data Preservation
U.S. Geological Survey—Earth MRI Program
U.S. Geological Survey—NCGMP
University of Alaska, Fairbanks
University of Idaho
University of Massachusetts, Lowell
University of Nevada, Las Vegas
Utah Geological Survey
Washington Geological Survey
Washington State University
Western State Colorado University
Western States Seismic Policy Council
Western Washington University
Wyoming Geological Survey
Yellowstone Volcano Observatory
Yukon Geological Survey
FINANCIALS

FY 2022 Budget Table

<table>
<thead>
<tr>
<th>Category</th>
<th>Beginning Balance</th>
<th>Income or Appropriations</th>
<th>Actual</th>
<th>Expense</th>
<th>Ending Balance</th>
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<td>Personnel</td>
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<td>Operating Expense</td>
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<td>Local Service</td>
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<td>Service Center</td>
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<td>Restricted Gifts</td>
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<td>Sponsored Programs</td>
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<td>TOTAL</td>
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<td>$2,192,048.49</td>
<td>$2,192,048.49</td>
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</table>

Trends in Expenditures

FY 2023 Budget Request

The FY 2023 budget request was limited to a 3.1% increase per the Governor’s Office directives. After working with the University and State Board of Education on several rounds of refinements and changes to a larger initial request, the final recommended and appropriated budget was $1,230,200. IGS was allocated $1,191,500 in personnel costs, which saw a reduction of $4,400 in variable benefit costs, an increase of $10,400 in health benefit costs, and $67,900 for a 5% change in employee compensation (CEC), as recommended by the Governor. Other Expense (OE) allocation was increased by $28,000 to total $38,700. Due to the 3.1% increase limitation, IGS did not request any one-time Capital Outlay funding. The Governor’s 5% CEC recommendation was implemented by IGS at or exceeding the recommended rate. Approximately 32% of the CEC increase and 50% of OE are projected to be generated by grant-funded salary and benefit savings. The University of Idaho Office of Research and Economic Development allowed projected overspending as backed up by expected grant funds.
Sources of Funding

publication sales

Since its release in 2012, Geologic Map of Idaho (M-9) has continued to be the best-selling IGS publication.
PUBLICATIONS AND ACTIVITIES

Publications


Major-Oxide and Trace-Element Analyses for the Gem Stocks, Shoshone County, Idaho and the Sorrel Spring Syenitic Complex, Custer County, Idaho, by D. Kate Schalck, Christopher A. Tate, Jesslyn K. Starnes, and Reed S. Lewis: Idaho Geological Survey Digital Analytical Data 19, 2021.


Abstracts


Reports


Grants and Contracts

**Abandoned Mine Lands Project, Task 6:** R.S. Lewis (Idaho Department of Lands, April 2021-March 2023, $169,445).

**Data Preservation 14:** R.S. Lewis and V.S. Gillerman (U.S. Geological Survey Data Preservation Program, July 2021-July 2022, $68,505).

**Development of Idaho-sourced Rare Earth Elements Drilling and Extraction:** Award to University of Idaho, A. Mirkouei, PI, with Idaho Geological Survey co-PIs, C. Berti and V.S. Gillerman (Idaho Department of Commerce IGEM Program, March 2022 – March 2023, IGS portion is $64,264 of UI award of $348,241).

**Geologic Mapping in the Idaho Cobalt Belt I:** R.S. Lewis (U.S. Geological Survey Earth MRI Program, August 2019-January 2022, $100,000).

**Geologic Mapping in the Idaho Cobalt Belt II:** R.S. Lewis (U.S. Geological Survey Earth MRI Program, September 2021-August 2023, $100,000).

**Geologic Mapping in the Preston, Weiser, Salmon, and Elk City Areas and GeMS-compliant Database Work:** R.S. Lewis and D.M. Feeney (U.S. Geological Survey STATEMAP Program, July 2020-October 2021, $318,392).

**Geologic Mapping in the Preston, Weiser, Salmon, and Elk City Areas and GeMS-compliant Database Work:** R.S. Lewis, D.M. Feeney, and R.V. Di Fiori (U.S. Geological Survey STATEMAP Program, July 2021-July 2022, $427,233).

**Groundwater Budget for the Big Lost River Valley:** A.L. Clark (Idaho Department of Water Resources, December 2018 – October 2021, $125,000).


**Petrochemical Study of Magnetite in the Iron Creek Co-Cu Area, Lemhi County:** V.S. Gillerman (Electra Battery Materials Corporation, December 1, 2021–December 31, 2022, $16,459).


Presentations


**An Overview of Landslide Hazards in Idaho:** by Zach Lifton: U.S. Geological Survey Landslide Seminar, Online, April 2022.

**Earthquake Program Updates:** by Zach Lifton: Federal Emergency Management Agency Idaho State Consultation, Boise, July 2021.
Faults and Seismicity in Idaho, by Zach Lifton: Natrium Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 Probabilistic Seismic Hazard Analysis (PSHA) Workshop 1, Online, April 2022.


Idaho Mining and Exploration, 2021, by Virginia S. Gillerman: Society for Mining, Metallurgy, and Exploration Snake River Section, Pocatello, April 2022.


Education and Outreach Activities

Co-convener, University of Idaho/Washington State University Geology Seminar Series, 2021-2022 (R.V. Di Fiori).
Co-leader, University of Idaho Soils/Intermountain Tree Cooperative Field Trip, Grangeville, September 2021 (R.V. Di Fiori and R.S. Lewis).

Distributor, American Geosciences Institute Earth Science Week Toolkits, September 2021 (D.M. Feeney and K.M. Pekas).


Organizer, IGS Salmon Field Forum, Salmon, October 2021 (R.S. Lewis).

Organizer and Moderator, Geoscience Expert Panel Discussion, University of Idaho and Oklahoma State University, Online, April 2022 (Mary K. Tkach).


Presenter, Palouse Prairie Expeditionary Learning School, Moscow, October 2021(D.M. Feeney).

Vendors, Idaho Mining Conference, Boise, November 2021 (Reed S. Lewis, Jesslyn Starnes, and Christopher A. Tate).

Education and Outreach Presentations


Geologic Hazards in Idaho, by Zach Lifton: Boise State University Civil Engineering guest lecture, Boise, December 2021.

Geology of the Salmon Area, by Reed S. Lewis: IGS Salmon Field Forum, Salmon, October 2021.

Geology of the Salmon Area, by Reed S. Lewis: Salmon Valley Rockhound Meeting, Salmon, June 2022.


UAS for Geologic Hazards, by Zach Lifton: Boise State University Human-Environment Systems Drone Flight Planning and Operations class guest lecture, Boise, April 2022.

Media Interviews


Web Products


Oil and Gas Web Application, by Christopher A. Tate, Reed S. Lewis, Mark Barton, and Dustin Thomas: Idaho Geological Survey Web Application, https://www.idahogeology.org/WebMap/?show=oilgas, September 2021.

Select Aggregate Material Sources for Idaho, by Christopher A. Tate and Dustin Thomas: Idaho Geological Survey ArcGIS Online Web App Migration, April 2022.


Operational Improvements

Lightbox Photo Studio for Rock Samples and Thin Sections, by Mary K. Tkach, February 2022.

Modeling Watershed Basin Precipitation from National PRISM Data in Python for Use in the Big Lost River Basin Hydrogeologic Investigation and the Raft River Basin Hydrogeologic Investigation, by Christopher A. Tate and Alexis Clark, December 2021.

Redesign and Review of Historical Oil and Gas Data for Idaho: 1903-1988, by Christopher A. Tate, Reed S. Lewis, and Mark Barton: Idaho Geological Survey Web Application, October 2021.

Template for Idaho Geological Survey Images Data, by Reed S. Lewis, Russell F. Burmester, and Christopher A. Tate, February 2022.
Graduate Thesis Committees

Cameron Wallenbrock, M.S. Geology, Washington State University (R.S. Lewis).
Dana Drinkall, M.S. Geology, Idaho State University (Z.M. Lifton).
Isabelle Rein, M.S. Geology, Washington State University (R.S. Lewis).
John Murphy, M.S. Geology, Washington State University (R.S. Lewis).
Klementina Mato, M.S. Geology, University of Massachusetts at Lowell (R.S. Lewis).

Professional Activities

Affiliate Faculty, Boise State University (V.S. Gillerman, Z.M. Lifton).
Affiliate Faculty, University of Idaho (M.D. Barton, C. Berti, V.S. Gillerman, R.S. Lewis, Z.M. Lifton).
Affiliate Faculty, Washington State University (R.S. Lewis).
Certification, LiDAR Applications and Spatial Analyses in ArcGIS Pro, March 2022 (C.A. Tate).
Certification, Working with LiDAR in ArcGIS Pro, March 2022 (C.A. Tate).
Chairman, Alumni Advisory Board Communications Committee, Oklahoma State University Boone Pickens School of Geology (M.K. Tkach).
Co-chair, Idaho State Hazards Technical Working Group (Z. Lifton).
Director-at-Large, Alumni Advisory Board Executive Committee, Oklahoma State University Boone Pickens School of Geology (M.K. Tkach).
Fellow, Society of Economic Geologists (V.S. Gillerman).
Member, American Association of Petroleum Geologists (M.K. Tkach).
Member, American Exploration and Mining Association (V.S. Gillerman, R.S. Lewis).
Member, American Geophysical Union (C. Berti, R.V. Di Fiori, Z.M. Lifton).
Member, American Water Resources Association (A.L. Clark).
Member, Association for Women Geoscientists (M.K. Tkach).
Member, Association of American State Geologists (C. Berti).
Member, Basin and Range Province Earthquake Working Group (Z.M. Lifton).
Member, Collaborative Database Effort For Geology (CDEFG) Working Group (N. Hopkins, L. Tedrow).
Member, Eastern Snake Hydrologic Modeling Committee (A.L. Clark).
Member, Geological Society of America (C. Berti, R.V. Di Fiori, V.S. Gillerman, N. Hopkins, R.S. Lewis, Z.M. Lifton, J.K. Starnes).
Member, Geological Society of Nevada (V.S. Gillerman).
Member, Ground Water Monitoring Technical Committee (A.L. Clark).
Member, Idaho Association of Professional Geologists (Z.M. Lifton).
Member, Idaho Lidar LiDAR Consortium (Z.M. Lifton).
Member, Incorporated Research Institutions for Seismology (IRIS) Portable Array Seismic Studies of the Continental Lithosphere (PASSCAL) (C. Berti).

Member, National Ground Water Association (A.L. Clark).

Member, Society for Mining, Metallurgy, and Exploration and Boise Section of Society for Mining, Metallurgy, and Exploration (V.S. Gillerman).

Member, Tobacco Root Geological Society (R.V. Di Fiori).

Member, Treasure Valley Modeling Technical Advisory Committee (A.L. Clark).

Member, Western States Seismic Policy Council (C. Berti, Z.M. Lifton).

Member, Wood River Valley Modeling Technical Advisory Committee (A.L. Clark).

Member, Yellowstone Volcano Observatory (Z.M. Lifton).


Oregon Registered Professional Geologist (A.L. Clark).


Participant, Association of American State Geologist Fall Liaison, Online, September 2021 (C. Berti).

Participant, Association of American State Geologist Spring Liaison, Online, March 2022 (C. Berti).

Participant, American Exploration and Mining Association Annual Convention, Reno, Nevada, December 2021 (V.S. Gillerman).

Participant, Challenges and Opportunities for Idaho Water Resources Workshop, Online, April 2022 (A.L. Clark).


Participant, Geologic Mapping Forum, Online, Periodic (N. Hopkins).


Participant, Geological Society of America Joint Cordilleran/Rocky Mountain Sections, Las Vegas, Nevada, March 2022 (C. Berti).

Participant, Geological Society of Nevada Symposium, May 2022 (R.V. Di Fiori, V.S. Gillerman, R.S. Lewis).

Participant, GIS Managers Meeting, Online, Quarterly (N. Hopkins).

Participant, Idaho Mining Conference, Boise, November 2021 (C. Berti, V.S. Gillerman, R.S. Lewis).

Participant, Idaho Oil and Gas Commission Meetings, Boise, Bi-monthly (M.D. Barton).

Participant, Idaho Water Supply Outlook Meetings, Online, February and March 2022 (A.L. Clark).


Participant, National Geological Map Database Webinar on STATEMAP Deliverables, November 2021 (N. Hopkins).

Participant, Short Course on Structural Geology for Exploration and Mine Geologists, Lowell Program in Economic Geology, Tucson, Arizona, March 2022 (R.V. Di Fiori).

Participant, StockPulse Silver Symposium, Coeur d’Alene, September 2021 (V.S. Gillerman).

Remote Pilot Certificate, Federal Aviation Administration (Z.M. Lifton).

Representative, UNAVCO WinSAR Consortium (Z.M. Lifton).

Reviewer, Montana Bureau of Mines and Geology article (V.S. Gillerman).


Washington Registered Geologist with Hydrogeologist Specialty (A.L. Clark).

Washington Registered Professional Geologist (Z.M. Lifton).

Wilderness First Responder, National Outdoor Leadership School (NOLS) (Z.M. Lifton).